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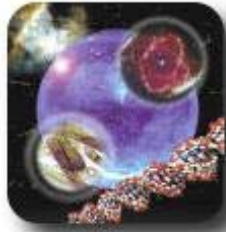
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Amanda's Halo: Seeing Through the Earth



Summary: Astronomers unveiled their first nearly-completed sky map using a novel Antarctic telescope not to look up, but to look down and through the Earth's core. Working on a forty-year dream to detect some of the most violent events from the galactic past, the astronomers use the South Pole ice sheet to look for the ghostly sub-atomic particle called a neutrino.

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Amanda's Halo

Seeing Through the Earth

based on UW-Madison report

Astronomers unveiled their first nearly-completed sky map using a novel Antarctic telescope not to look up, but to look down and through the Earth's core. Working on a forty-year dream to detect some of the most violent events from the galactic past, the astronomers use the South Pole ice sheet to look for the ghostly sub-atomic particle called a neutrino.

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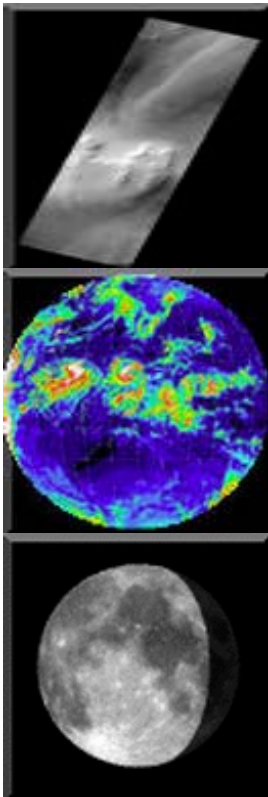
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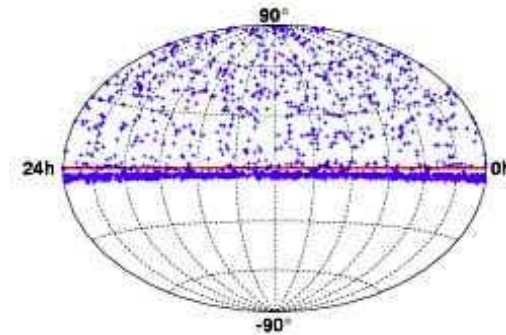
and views of today's [Mars](#), [Odyssey image](#), [Earth](#), [Moon](#) and [Sun](#)



A novel telescope that uses the Antarctic ice sheet as its window to the cosmos has produced the first map of the high-energy neutrino sky. Buried 1.5 km (0.9 miles) below the South Pole, the telescope looks not up, but down and through the Earth's core.

The sky map, unveiled for astronomers July 15 at a meeting of the International Astronomical Union, provides astronomers with their first tantalizing glimpse of very high-energy neutrinos, ghostly particles that are believed to emanate from some of the most violent events in the universe - crashing black holes, gamma ray bursts, and the violent cores of distant galaxies. The capability to view the sky at small enough wavelengths to image neutrinos reveals a different picture of the universe, one tuned to key in on the most violent and potentially formative events. The dream for such a different kind of sky view dates back more than 40 years old.

"This is the first data with a neutrino telescope with realistic discovery potential," says Francis Halzen, a University of Wisconsin-Madison professor of physics, of the map compiled using AMANDA II, a one-of-a-kind telescope built with support from the National Science Foundation (NSF) and composed of arrays of light-gathering detectors buried in ice 1.5 kilometers beneath the South Pole. "To date, this is the most sensitive way ever to look at the high-energy neutrino sky," he says.

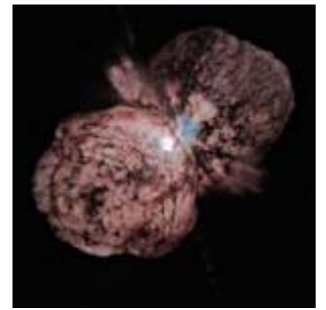


AMANDA neutrino skymap. Sky plot in equatorial coordinates of AMANDA events recorded in 2000. Blue marks represent recorded neutrino sources and their distribution relatively uniformly in the regions mapped.

Credit: [Hauschildt](#), et al.

unimpeded through planets, stars, the vast magnetic fields of interstellar space and even entire galaxies. That quality - which makes them very hard to detect - is also their greatest asset because the information they harbor about cosmologically distant and otherwise unobservable events remains intact.

The map produced by AMANDA II is preliminary, Halzen emphasizes, and represents only one year of data gathered by the icebound telescope. Using two more years of data already harvested with AMANDA II, Halzen and his colleagues will next define the structure of the sky map and sort out potential signals from statistical fluctuations in the

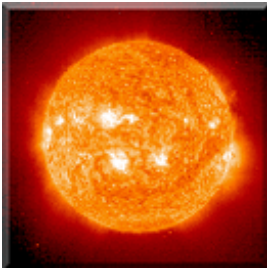


Supernova remnants are proposed as one intense sources for accelerating cosmic rays and neutrinos

Credit: Hubble

The ability to detect high-energy neutrinos and trace them back to their points of origin remains one of the most important quests of modern astrophysics. The mechanism for accelerating cosmic rays to such high energy (10 giga-electron volts, GeV) puzzles theorists. Cosmic rays are thought to be accelerated in the shock fronts of exotic supernova remnants, microquasars, or in core regions of intense magnetic fields.

Because cosmic neutrinos are invisible, uncharged and have almost no mass, they are next to impossible to detect. Unlike photons, the particles that make up visible light, and other kinds of radiation, neutrinos can pass



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Ion:

An atom with one or more electrons removed (or added), giving the atom a positive (or negative) charge.

Space Channel

present map to confirm or disprove them.

The significance of the map, according to Halzen, is that it proves the detector works. "It establishes the performance of the technology," he says, "and it shows that we have reached the same sensitivity as telescopes used to detect gamma rays in the same high-energy region" of the electromagnetic spectrum. Roughly equal signals are expected from objects that accelerate cosmic rays, whose origins remain unknown nearly a century after their discovery.

Sunk deep into the Antarctic ice, the AMANDA II (Antarctic Muon and Neutrino Detector Array) Telescope is designed to look not up, but down, through the Earth to the sky in the Northern Hemisphere. The telescope consists of 677 glass optical modules, each the size of a bowling ball, arrayed on 19 cables set deep in the ice with the help of high-pressure hot-water drills. The array transforms a cylinder of ice 500 meters in height and 120 meters in diameter into a particle detector.

The glass modules work like light bulbs in reverse. They detect and capture faint and fleeting streaks of light created when, on occasion, neutrinos crash into ice atoms inside or near the detector. The subatomic wrecks create muons, another species of subatomic particle that, conveniently, leaves an ephemeral wake of blue light in the deep Antarctic ice. The streak of light matches the path of the neutrino and points back to its point of origin.

Because it provides the first glimpse of the high-energy neutrino sky, the map will be of intense interest to astronomers because, says Halzen, "we still have no clue how cosmic rays are accelerated or where they come from."

The fact that AMANDA II has now identified neutrinos up to one hundred times the energy of the particles produced by the most powerful earthbound accelerators raises the prospect that some of them may be kick-started on their long journeys by some of the most supremely energetic events in the cosmos. The ability to routinely detect high-energy neutrinos will provide astronomers not only with a lens to study such bizarre phenomena as colliding black holes, but with a means to gain direct access to unedited information from events that occurred hundreds of millions or billions of light years away and eons ago.



"This map could hold the first evidence of a cosmic accelerator," Halzen says. "But we are not there yet."

The hunt for sources of cosmic neutrinos will get a boost as the AMANDA II Telescope grows in size as new strings



The Greek symbol for the neutrino, shown against a background of rainbow and Antarctic halo from light scattered from ice-crystals



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The planned IceCube neutrino observatory, composed of strings of neutrino detectors embedded in the ice under the South Pole.

Credit: University of Wisconsin

order of 10 neutrinos a year. That's not good enough."

of detectors are added. Plans call for the telescope to grow to a cubic kilometer of instrumented ice. The new telescope, to be known as IceCube, will make scouring the skies for cosmic neutrino sources highly efficient.

"We will be sensitive to the most pessimistic theoretical predictions," Halzen says. "Remember, we are looking for sources, and even if we discover something now, our sensitivity is such that we would see, at best, on the order of 10 neutrinos a year. That's not good enough."

What's Next

As a research bonus from the Antarctic research, a novel biological lab has grown up around the AMANDA astronomers. Several years ago, radar images of the ice around the South Pole showed evidence of a [subglacial lake](#) about 10 kilometers from the pole. The temperature there should be about the same as the temperature at the AMANDA site, meaning that the under-ice lake would likely be a frozen mixture of ice and sediment in order to explain the flat terrain indicated by radar images. The permafrost, similar to that found in Arctic regions of North America and Europe, may be 10 or 20 million years old, dating from before the Antarctic continent was covered by a sheet of ice.

Since any contamination introduced by drilling into the permafrost would not travel far, the site would make a good place to test such techniques in preparation for drilling into [Lake Vostok](#), a huge, Lake Ontario-sized subglacial sea that has intrigued scientists since it was detected four kilometers below the ice in 1996. Proposals to drill into Lake Vostok have met with opposition because of the danger of contamination. In addition, many of the nearly 100 under-ice seas discovered to date may be interconnected, so contaminating one could contaminate them all. An international committee is discussing the issue, which may delay drilling for a decade.



Amanda neutrino detector being lowered into subsurface observatory

Astrobiologists are interested in the kinds of exotic microbes that might live inside solid ice, either as dormant spores or at a low level of activity. [Drilling](#) in Antarctic ice, including to within about 100 meters of Lake Vostok, has turned up some bacteria, according to Russian scientists, but all were known before. Bacteria also have been found in ocean ice. Inspired by finding the sub-glacial lake, scientists hope to discover new species in solid ice, analogous to the novel thermophiles found in hot seafloor vents living at temperatures above the sea-level boiling point of water (100 C or 212 F).

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- [Cosmic dust culprit unmasked](#) - The Guardian (UK). (Jul 17, 2003)
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Note: *Stellar Evolution*: [2003-07-17]

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